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ECONOMIC CONSIDERATIONS

in management of
Douglas-fir growing stock

- - - A CASE STUDY

by Norman P. Worthington and John Fedkiw

SUMMARY

Thirteen years of commercial thinning beginning in 45- to 55-year-old Douglas-fir in central western Washington have demonstrated the silvicultural practicality and economic superiority of thinning over no thinning. Economic analysis indicates management with thinnings increased total net income after taxes by 3.6 percent. The increase is chiefly attributable to salvage of mortality through light, frequent thinnings. The increase in total net income probably would have been greater had the initial thinning been delayed 3 to 5 years, if poles and piling had been selected and sold separately, and if grade improvement on the better trees arising from redistribution of growth had been quantified.

Large and increasing capital investment in aging residual stands raises questions concerning economic efficiency of growing-stock capital and best time for its disinvestment and establishment of a new stand. The younger stands, now 55 years old, have a current volume growth percent of 4.0 and a value growth percent at least 1 percent greater due to increasing tree size and quality and to expected increases in young-growth stumpage prices. The problem is largely with the older stand, which is now 70 years old. Management of this older stand was examined under four alternatives: immediate disinvestment and regeneration; continuation of present light thinnings for 20 years; somewhat heavier thinning in the next 20 years; disinvestment 20 years hence without further thinning. Criterion for the management decision was attainment of a 3.5-percent after-tax return in the next 20 years. If the landowner's ordinary income tax rate is 50 percent, 3.5 percent after tax is equivalent to 7 percent before taxes.

Analysis showed that continued light thinning is the economically superior alternative, promising a 5.0-percent earning rate under a gradual 50-percent stumpage price increase, or a 3.0-percent rate at a constant stumpage price level. Thus, under the 3.5 criterion, the 70-year-old stand is financially mature and ready for regeneration unless stumpage prices increase. Analysis of the unthinned check areas indicates an earning rate substantially below the 3.5-percent rate and hence attainment of economic maturity prior to 1961.

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INTRODUCTION

Research in the management of young Douglas-fir has been conducted on the McCleary Experimental Forest[1] in western Washington since 1949.

To date, this research has been directed primarily toward increasing the productivity of young-growth stands through periodic commercial thinnings and toward determining whether such thinning operations can be profitable.

Experience has demonstrated the economic and silvicultural practicality of commercial thinning operations in Douglas-fir from 45 to 70 years old. On the other hand, the aging of the residual stands and their large capital investment have raised questions concerning the earning rate of the growing-stock capital and the optimum time or circumstances for harvesting the present stand and establishing a new one.

This paper describes 13 years of commercial thinning at McCleary and explores selected management alternatives for the present stand, now

[1] Maintained by the U. S. Forest Service in cooperation with the Simpson Timber Co.

55 to 70 years old and averaging 47,000 board feet per acre. Answers are sought for two specific questions:

1. Has commercial thinning from 1949 to 1961 been financially superior to holding the growing stock without thinnings? If so, by how much?

2. What is the best financial alternative for McCleary stands in the next 20 years: clear cutting and regenerating now; holding the growing stock without thinning to 1981; continuing a regime of light to medium thinnings?

Many timberland owners in the Douglas-fir region have young-growth stands similar to those described in this case history. Perhaps the method offered here for examining management alternatives can be adapted by landowners to their own situations in planning the management of their young-growth Douglas-fir stands.

Description of the Forest

The forest consists of 340 acres of gentle-to-medium slopes in an elevation range from 300 to 600 feet. The soil is chiefly Olympic loam. The forest is largely Douglas-fir that originated after cutting in the western portion and after burning in the eastern portion. Two 1961 age classes have resulted: 55 years on the logged area and 70 years on the burned. Taken as a whole, the forest is well stocked.

Site index averages 180 feet (high site II) in the older stand and 170 feet (medium site II) in the younger. Mixtures of cedar, hemlock, and alder are common in the 55-year-old stand. Alder is dominant in the north quarter along the principal drainage. A June 1948 inventory[2] showed 2,147,000 cubic feet, or 9,423,440 board feet (Scribner rule), for all species (table 1). Douglas-fir, the predominant species, accounted for 68 percent of the cubic volume; alder, for 16 percent; and other species, for 16 percent.

Table 1.—Timber inventory, McCleary Experimental Forest, June 1948

Species	Volume			
	Cubic[1]		International 1/4-inch kerf[2]	Scribner rule[3]
	Cu. ft.	Percent	Bd. ft.	Bd. ft.
Douglas-fir	1,468,256	68	9,492,460	7,032,900
Cedar	189,890	9	800,020	522,240
Hemlock and spruce	123,080	6	788,460	647,360
Alder	338,708	16	1,240,184	1,127,440
Miscellaneous hardwoods	27,200	1	102,850	93,500
Total	2,147,134	100	12,423,974	9,423,440
Per acre	6,315	--	36,541	27,716

[1]Cubic-foot volume is for trees 6 inches d.b.h. and larger to a 4-inch top.
[2] All conifers 8 inches d.b.h. and larger to a minimum top diameter of 6 inches; older and miscellnoeous hardwoods, 12 inches d.b.h. and larger to a minimum top diameter of 8 inches.
[3] All conifers 10 inches d.b.h. and larger to a minimum top diameter of 8 inches; all older and miscellaneous hardwoods 12 inches d.b.h. and larger to a minimum top diameter of 8 inches.

[2] Data are from 170 concentric 1/10- and 1/5-acre plots spaced 264 feet apart in rows 330 feet apart. Trees 5.1 to 15.0 inches d.b.h. were tallied on the smaller area, and all trees over 15.0 inches were counted on the larger. On 25 percent of the plots, each tree was tagged and measured to the nearest one-tenth inch; on the remainder, measurement was by 2-inch classes, and individual tree identity was not preserved.

The Management Practiced

In 1949, a policy decision was made to hold all stands for a decade or more. Variation in management was not proposed because stands were uniformly well stocked and fairly well along in age. Accordingly, light thinning, involving little or no risk of loss to the residual stand, was chosen as the appropriate management practice for the next decade or so.

To facilitate study of commercial thinning operations and the impact of such thinning on the development of the residual stands, the coniferous portion of the forest was divided into two blocks (fig. 1) constituting fairly distinct types and conditions. In each block, a check area was held undisturbed to compare with the development of the residual stand following commercial thinning:

Type description	Block	Thinning area	Check area
		— — — Acres — —	
Mixed conifers and alder age 56 in 1961	A	85	15
Even-aged Douglas-fir, age 69 in 1961	B	115	30
Total acres		200	45

Blocks A and B, chiefly Douglas-fir, were each divided into five compartments to systematize annual thinning operations. A compartment of about 40 acres in each block was thinned annually so that each block was covered every 5 years. The 1961 harvest completed 13 years of commercial thinning.

No cuttings have been made on the remaining 95 acres of the forest, where the stand is predominantly alder in mixture with conifers.

Thinning Yields

Thinnings produced 2,286,945 board feet, Scribner rule (table 2). The greater annual yields in the first thinning cycle, 1949-53, arose largely from the heavier volumes harvested on road rights-of-way and from a heavier initial thinning. During the second and third thinning cycles, annual thinning yields have varied between 114,000 and 144,000 board feet, averaging about 75 percent of the annual increment.

Table 2.—Thinning yields, 1949-61, McCleary Experimental Forest

Year	Douglas-fir[1]	Alder	Total
	— — — Board feet, Scribner rule — — —		
1949	199,831	0	199,831
1950	422,271	6,251	428,522
1951	257,000	15,000	272,000
1952	220,000	22,000	242,000
1953	141,791	19,400	161,191
1954	95,726	22,385	118,111
1955	102,000	11,570	113,570
1956	106,000	14,000	120,000
1957	115,000	6,000	121,000
1958	117,000	27,000	144,000
1959	101,730	20,500	122,230
1960	111,240	16,600	127,840
1961	106,650	10,000	116,650
Total	2,096,239	190,706	[2]2,286,945

[1] Less than 5 percent hemlock and cedar.
[2] Includes 210,000 board feet cut from rights-of-way, 9.2 percent of total cut.

Trees that were dying, misshapen, or broken predominated in the first thinnings. Rough, limby dominants, whose removal was expected to release trees of better form and quality, were taken later. In addition, other trees were cut to improve spacing where the residual trees were judged capable of good increment response.

Road Development and Maintenance

Roads were constructed to Forest Service single-lane standards by the operator who purchased the stumpage. To date, 1.95 miles (80 percent surfaced) have been completed. To adequately serve the 340-acre forest, the system should be extended to 2.4 miles, which would be an intensity of 142 acres per mile or 4.32 miles per section. Then, no point would be over 1,000 feet from a road.

McCLEARY EXPERIMENTAL FOREST
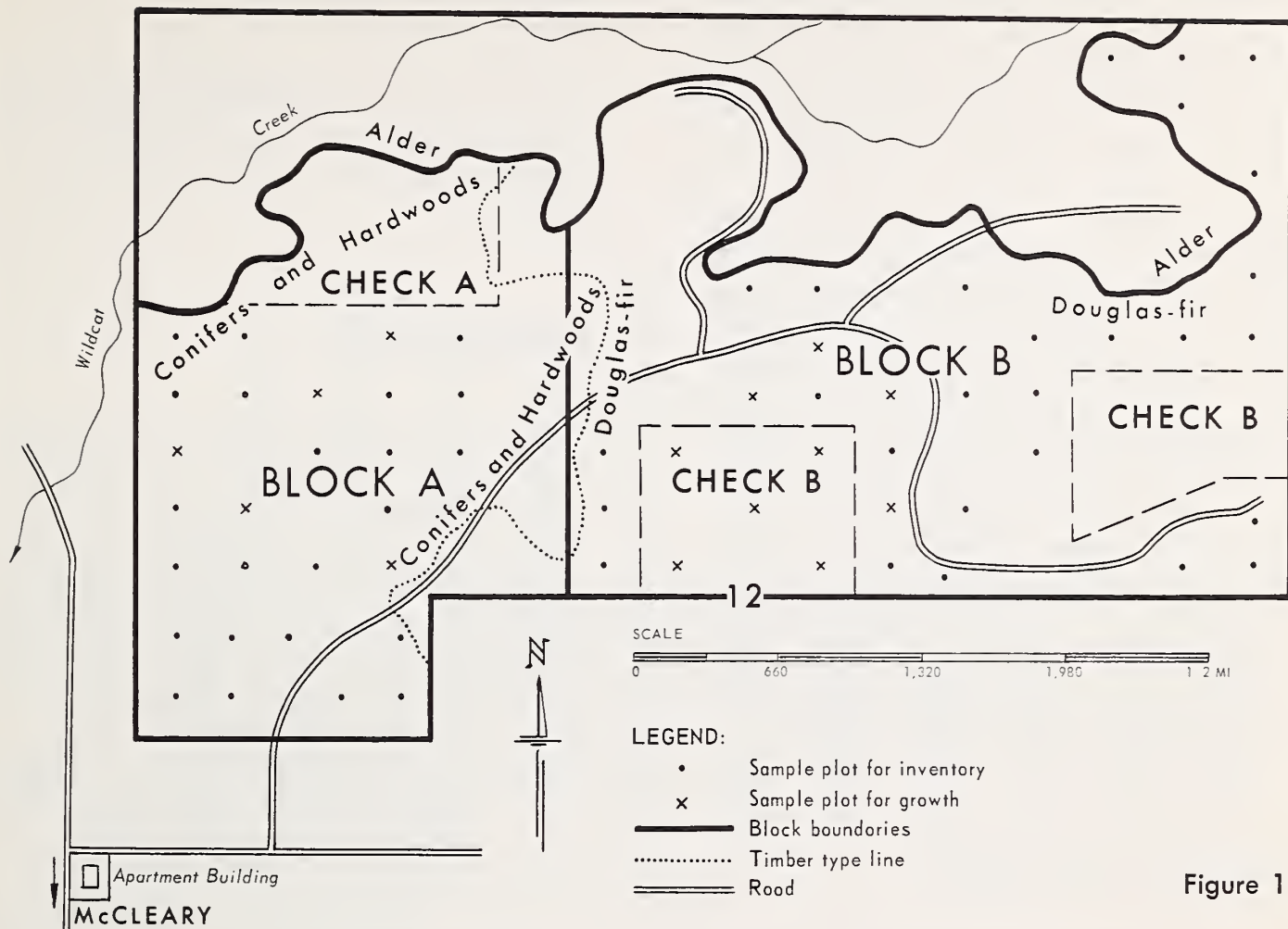## GRAYS HARBOR COUNTY, WASHINGTON
T. 18 N., R. 5 W., W.M.

Figure 1.

Road cost, including location and engineering, was $6,336 per mile, and annual maintenance costs have averaged $35 per mile since the 1.95 miles of road were completed in 1952 (table 3). The total road investment was $12,354.75, amounting to $1.06 per thousand board feet, Scribner rule, when prorated over past thinnings and the 1961 inventory volume for blocks A and B (table 6).

Table 3.—Road expenditures and stumpage revenues, McCleary Experimental Forest, 1949-61

Year	Road construction[1]		Annual road maintenance	Stumpage revenue[2]	
	Annual	Cumulative		Annual	Cumulative
	— — — — — — — — — — Dollars — — — — — — — — —				
1949	559.27	559.27	0	1,198.99	1,198.99
1950	4,323.60	4,882.87	0	3,063.66	4,262.65
1951	3,388.36	8,271.23	0	3,306.00	7,568.65
1952	2,640.81	10,912.04	50.00	3,234.00	10,802.65
1953	763.51	11,675.55	0	1,893.00	12,695.65
1954	216.11	11,891.66	0	1,272.04	13,967.69
1955	237.48	12,129.14	0	1,550.50	15,518.19
1956	225.61	12,354.75	187.00	1,727.00	17,245.19
1957	0	12,354.75	267.00	1,617.00	18,862.19
1958	0	12,354.75	100.00	1,686.00	20,548.19
1959	0	12,354.75	20.00	1,628.45	22,176.64
1960	0	12,354.75	0	1,584.74	23,761.38
1961	0	12,354.75	57.00	1,644.75	25,406.13

[1] Includes $1,000-per-mile allowance for road location and engineering or a total of $1,950 allocated in proportion to annual expenditure.
[2] Before income taxes. Maximum reduction of stumpage revenues would be 25 percent. The actual income tax impact for any individual case would be somewhat lower, depending upon depletion rate and the income tax bracket of the owner.

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Net stumpage revenue ($7,127, col. 11, table 7), derived from clearing rights-of-way and from thinnings during the first 5-year cycle, was sufficient to fund 61 percent of the road investment cost in that period (tables 3 and 7). By the end of the second cycle, net revenue was sufficient to fund 91 percent of the total road investment. The road investment actually is not an extra cost but an advance outlay that would otherwise have to be made when the stand was clear cut. In this light, management of young growth in the first two thinning cycles amounts to a conversion of timber capital into road capital. The latter is more productive since it makes possible an increase in income and timber yield through salvage of accumulated mortality and capture of additional mortality that would occur before final harvest. In addition, advance roading can reduce risks and costs of protection and administration. Increased yields plus reduced costs and risks are a net gain over income that would have been produced had the forest been left unroaded until time of final harvest.

Markets and Prices

For the first 10 years, annual stumpage sales were made to a nearby small mill operator, who either logged the timber with his own crew or subcontracted the work. The operator sold some of the better timber as peeler logs. The bulk, however, was processed as lumber or cants through his sawmill and sold locally or to an Olympia concentration yard. In 1960 and 1961, stumpage was sold to a logger who, in turn, sold his logs to other mills.

All stumpage sales were for a lump sum. Sale volume was determined from an individual tree count (by d.b.h.) made when the timber was marked.

Conifers down to 9.0 inches d.b.h. were marked for cutting and utilized to a 6- to 7-inch minimum top diameter, since the only market outlet was for saw logs and veneer logs. Alder, to a 6-inch minimum top, usually was sold as pulp logs.

4

The annual stumpage rates realized from Douglas-fir thinnings have ranged from $6 per thousand board feet in 1949 to a maximum of $15.50 in 1956 (fig. 2). The alder price range has been narrower—from $4 to $7.50 per thousand board feet. Total stumpage receipts from 1949 through 1961 were $25,406.13 for 2,286,945 board feet of all species (tables 2 and 3).

Logging Costs

Records of logging costs for two successive 3-year periods, 1950-52 and 1953-55, are summarized in table 4. Average total costs per thousand board feet between the two periods declined 5 percent to $25.97. Labor efficiency improved 21 percent in the same period, but this improvement was offset in part by a 42-cent increase in the average hourly wage.

Table 4.—Average thinning costs and production efficiency for two 3-year periods, McCleary Experimental Forest[1]

Item	Man-hours per thousand board feet		Cost per thousand board feet	
	1950-52	1953-55	1950-52	1953-55
Felling and bucking	1.66	1.46	$4.57	$4.34
Skidding	1.88	1.82	6.64	8.21
Loading	1.03	.83	3.97	2.91
Trucking	.94	.86	4.35	2.97
Moving and road maint.	1.02	.29	1.77	1.18
Administration	.81	.55	1.29	1.53
Taxes	--	--	1.56	1.83
Subtotal	7.34	5.81	24.15	22.97
Profit allowance	--	--	3.00	3.00
Total	7.34	5.81	27.15	25.97

[1] Adapted from table 1 of: Worthington, Norman P. Some economic considerations in thinning Douglas-fir. U. S. Forest Serv. Pac. NW. Forest & Range Expt. Sta. Res. Note 137, 7 pp. 1957.

Currently, average total costs per thousand board feet are from 5 to 10 percent higher than in 1950-55. Labor efficiency is further improved, but average hourly wages have increased more.

In the 1950-52 period, average cut per acre was 5,603 board feet, including right-of-way

ANNUAL STUMPAGE PRICES,
McCLEARY EXPERIMENTAL FOREST,
1 9 4 9 - 6 1

20 DOLLARS PER M BD. FT.

DOUGLAS-FIR

ALDER

15

10

5

0

1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961
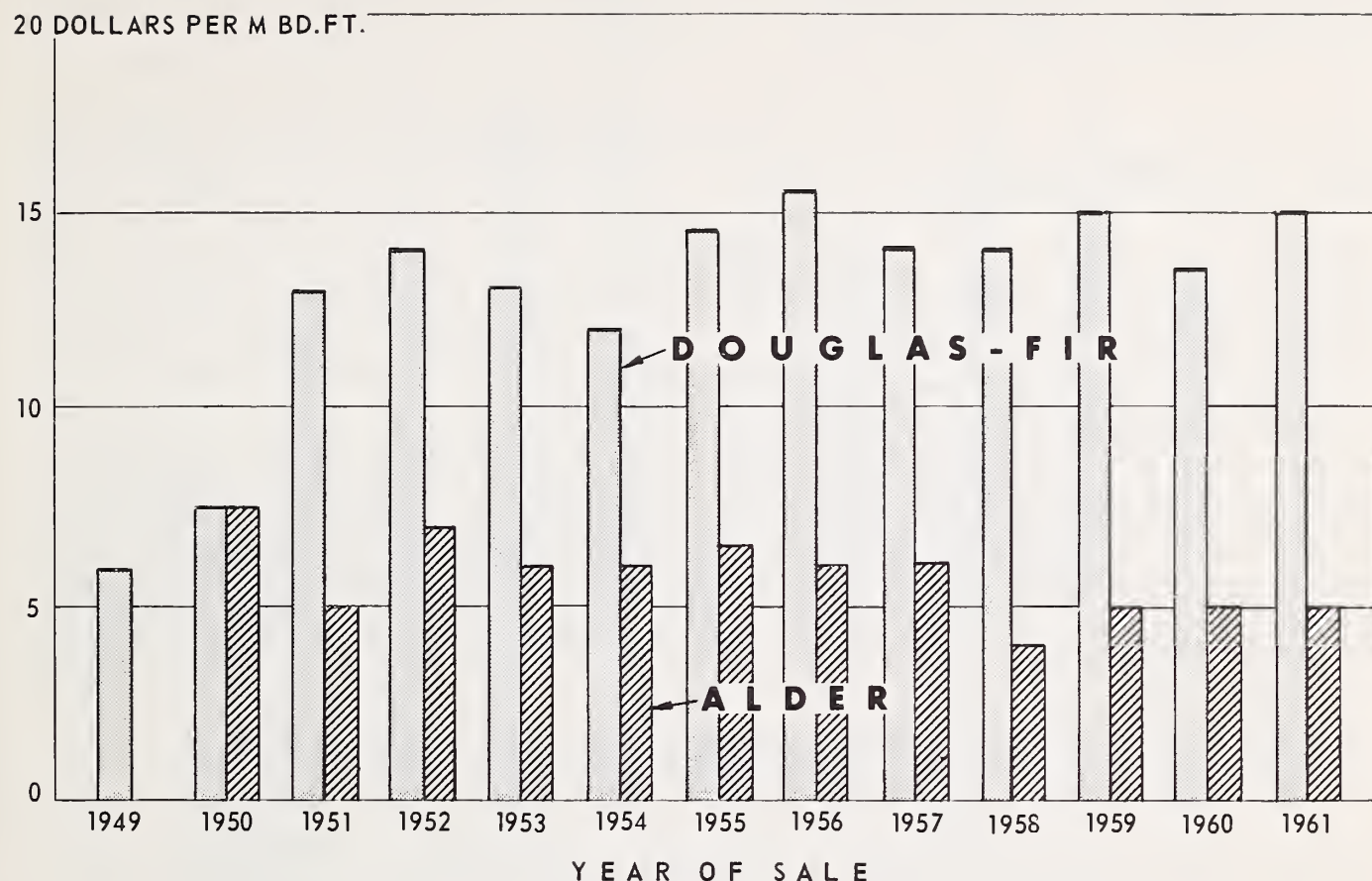
YEAR OF SALE

Figure 2.—Annual stumpage prices, McCleary Experimental Forest, 1949-62.

timber. The total harvest was 814,000 board feet, and average d.b.h. of cut trees was 16.8 inches. The average cut per acre in the second period was 3,098 board feet, mostly from second thinnings. The total harvest was 416,000 board feet, and average d.b.h. for cut trees was 15.6 inches.

The great improvement in labor efficiency in the second period is attributed largely to two basic changes: (1) reduction of logging crew to two or three men (from a former five to nine men), accompanied by less specialization of labor, better coordination among the crew, and less loss of labor output during breakdowns; (2) shift from "hot" logging to decking along roadside and loading with a mobile loader, thus reducing skidding time and eliminating waiting time due to intermittent shortages of logs to load out.

Direct Management Expenses

The principal expenses in managing second-growth timber are costs of marking, selling, and supervising the thinning operation. These are in addition to costs of road location and engineering, which are part of the road investment.

The cost of marking 184,000 board feet prepared for sale in 1962 was estimated at $1.05 per thousand. This is based on 4 man-days of field work, 200 miles of auto transportation, $12.25 for materials and equipment, $18 for office work, and $26 for payroll taxes and other burden. The costs of selling and supervision, $1.20 per thousand board feet, include 6 man-days, 300 miles of auto transportation, and $40 for payroll taxes and other burden. Thus, the total direct management expense is estimated

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at $2.25 per thousand board feet, log scale, Scribner rule. This cost is based on use of resident personnel. Similar work done by consultants, excluding allowance for profit, would cost about 20 percent more, or $2.70, due to greater travel and associated expense.

Fixed Ownership Expenses

Fixed expenses are those which must be incurred and paid whether young-growth timber is managed for thinnings or held for clear cutting. These include protection, ad valorem taxes, and administration of the property. Table 5 shows the schedule of costs incurred for these purposes from 1949 to 1961. It also includes yield tax payments, which are a direct expense of thinning since they are paid only when timber is harvested.

thinnings was financially superior to holding the growing stock without thinning for the period 1949-61. The economic advantage of the thinning system is estimated at $5,860 for blocks A and B in 1961, or about $1.84 per acre per year.

In this analysis, the owner is assumed to be a private landowner who builds the roads on his property, sells stumpage to a logger or contractor, and is in the 50-percent income tax bracket. This assumption is presumed to be consistent with ownership of a half section or more of second-growth Douglas-fir, which has a current liquidation value approaching $1,000 per acre.

At the end of 1961, the net cumulative cash exceeded road investment requirements by $1,462. Because the return from the best alternative investment of funds used to build roads is assumed to have been 3.5 percent com-

Table 5.—Fixed annual expenses of ownership, including yield taxes, McCleary Experimental Forest, 1949-61

Year	Fire patrol[1]		Ad valorem taxes paid[2]	Yield tax on harvested timber		Estimated annual expense of administration
	Payments	Rate per acre		Payments	Tax rate	
	Dollars	Cents	Dollars	Dollars	Percent	Dollars
1949	20.80	6.5	39.11	32.40	3.0	150
1950	20.80	6.5	31.71	115.50	4.0	150
1951	25.60	8.0	39.04	156.00	5.0	150
1952	28.80	9.0	31.88	227.00	7.0	150
1953	28.80	9.0	47.94	84.48	8.0	150
1954	28.80	9.0	34.78	58.21	10.0	150
1955	28.80	9.0	18.82	96.03	9.0	150
1956	28.80	9.0	16.56	180.00	10.0	150
1957	28.80	9.0	14.83	139.70	11.0	150
1958	28.80	9.0	20.52	78.91	12.0	150
1959	32.00	10.0	18.80	165.75	12.5	150
1960	33.60	10.5	17.72	150.71	12.5	150
1961	32.00	10.0	15.56	180.51	12.5	150
Total	366.40	--	347.27	1,665.20	--	1,950

[1] Paid to Washington Forest Fire Association whose rates are approximately $0.01 more than State fire patrol charge.
[2] Two hundred acres classified under State Reforestation Act in 1946; 140 acres classified in 1955. Year-to-year variation is largely due to changes in the annual tax rate.

Analysis of Financial Experience

The financial experience in thinning blocks A and B has been analyzed (tables 6 and 7) and later compared with the expected experience had these stands not been thinned. The comparison shows that management with light

pounded after taxes on the earnings,[3] the gain in cash at the end of 1961 ($160) is lower. The road investment, however, is completely amortized, and the road is adequate for final harvest purposes.

[3] This is equivalent to a 7-percent rate of return before application of the 50-percent personal income tax assumed for this case.

Table 6.—Calculation of net stumpage revenue after tax on capital gain, blocks A and B, McCleary Experimental Forest, 1949-61

Year	Thinning yields	Inventory		Stumpage revenue	Timber depletion[1]	Capital gain[2]	Road depreciation[3]	Direct selling expense[4]	Taxable gain[5]	Tax on capital gain[6]	Net revenue after tax on capital gain
		Thinned	Unthinned								
	M Bd. ft.	— M Bd. ft. —		— — — — — — — — — — Dollars — — — — — — — — — — — —							
1949	200	7,701	7,701	1,199	200	999	212	450	337	84	253
1950	429	--	--	3,064	429	2,635	455	965	1,215	304	911
1951	272	--	--	3,306	272	3,034	288	612	2,134	534	1,600
1952	242	--	--	3,234	242	2,992	257	544	2,191	548	1,643
1953	161	--	--	1,893	161	1,732	171	362	1,199	300	899
1954	118	--	--	1,272	118	1,154	125	266	763	191	572
1955	114	--	--	1,550	114	1,436	121	256	1,059	265	794
1956	120	--	--	1,727	90	1,637	127	270	1,240	310	930
1957	121	--	--	1,617	91	1,526	127	272	1,127	282	845
1958	144	--	--	1,686	108	1,578	153	324	1,101	275	826
1959	122	--	--	1,628	92	1,536	129	274	1,133	283	850
1960	128	--	--	1,585	96	1,489	136	288	1,065	266	799
1961	117	[7]9,427	[7]10,998	1,645	88	1,557	123	263	1,171	293	878
Total	--	--	--	25,406	2,101	23,305	2,424	5,146	15,735	3,935	11,800

[1] Calculated at $1 per thousand for 7,701,000 board feet according to 1949 inventory. This is equivalent to a purchase cost of $31.40 per acre for timber. The depletion rate is adjusted for growth in 1956 to $0.75 per thousand.
[2] Stumpage revenue less depletion.
[3] Calculated at $1.06 per thousand on total road outlay of $12,355 and expected total harvest of 11,714,000 board feet.
[4] Calculated at $2.25 per thousand for marking, selling, and supervision of thinning sales.
[5] Capital gain less road depreciation and direct costs of thinning sales for realization of gain. These items are treated as offsets against capital gains where landowner sells stumpage and is not integrated. For an integrated owner, or an owner selling logs, these items would be treated as expenses against ordinary income for income tax purposes.
[6] One-half taxable gain times ordinary tax rate of owner (50 percent); or, in this case, 25 percent of taxable gain, the maximum capital gain tax rate.
[7] Based on weighted mean annual realized net growth of 1,260 board feet per acre for thinned stands; 1,035 board feet per acre for unthinned stands. The additional realized net growth arises from the capture of mortality through thinnings. Thirteen growing seasons are used.

Table 7.—Summary of financial experience for blocks A and B, McCleary Experimental Forest

Year	Net stumpage revenue after tax on capital gain[1]	Ordinary property expenses before taxes				Property expenses after taxes[3]	Net income from timber property[4]	Road depreciation	Timber depletion	Cash flow[5]	Road investment	Cumulative net cash flow	
		Fixed annual expense[2]	Road maintenance	Yield taxes	Total							Without interest[6]	With interest[7]
		— — — — — — — — — — — — — — — — — Dollars — — — — — — — — — — — — — —											
1949	253	210	0	32	242	121	132	212	200	544	559	-15	-15
1950	911	203	0	116	319	160	751	455	429	1,635	4,324	-2,704	-2,705
1951	1,600	215	0	156	371	185	1,415	288	272	1,975	3,388	-4,117	-4,214
1952	1,643	211	50	227	488	244	1,399	257	242	1,898	2,641	-4,860	-5,104
1953	899	227	0	84	311	156	743	171	161	1,075	764	-4,549	-4,972
1954	572	214	0	58	272	136	436	125	118	679	216	-4,086	-4,683
1955	794	198	0	96	294	147	647	121	114	882	237	-3,441	-4,202
1956	930	195	187	180	562	281	649	127	90	866	226	-2,801	-3,709
1957	845	194	267	140	601	300	545	127	91	763	0	-2,038	-3,076
1958	826	200	100	79	379	190	636	153	108	897	0	-1,141	-2,287
1959	850	201	20	166	387	193	657	129	92	878	0	-263	-1,489
1960	799	202	0	151	353	177	622	136	96	854	0	591	-687
1961	878	198	57	181	436	218	660	123	88	871	0	1,462	160
Total	11,800	2,668	681	1,666	5,015	2,508	9,292	2,424	2,101	13,817	12,355	1,462	160

[1] From last column, table 6.
[2] Expense of management and conservation of a property. Includes fire patrol, ad valorem taxes, and $150 per year for general administration.
[3] Property expenses are offset against ordinary income, which is taxable at the rate of 50 percent in this case. Thus, the net cost to owner for these expenses after taxes is 50 percent of the actual outlay.
[4] Net stumpage revenue after tax on capital gain less property expenses after taxes.
[5] Net income from timber property plus road depreciation and timber depletion. These funds are available for reinvestment or spending by owner.
[6] Cash flow less cash outlay for road investment. Negative values indicate cumulative road investment exceeds cumulative cash flow.
[7] Includes 3.5-percent interest charge on the undepreciated road balance. The 3.5-percent rate is taken as the net cost of interest charges after taxes.

Complete financial comparison of the alternative systems of management required evaluation of the growing stock as of the end of 1961. For the thinned stand, which had an average d.b.h. of 19.1 inches, Douglas-fir was valued at $27.05 per thousand board feet[1]. Other conifers were valued at 65 percent of this, or $17.85 per thousand, and alder at $4.75 per thousand, the average experience of the previous 5 years. The weighted average price of the thinned residual stand was, accordingly, $25.72 per thousand board feet.

Total yields at the end of 1961 were as follows:

	Thousand board feet	Percent
Thinned stand:		
Thinnings (1949-61)	2,287	19.5
Residual stand (1961):		
Douglas-fir	8,162	69.7
Other conifers	1,223	10.4
Alder	42	.4
Total residual stand	9,427	80.5
Total yield	11,714	100.0
Unthinned stand:		
Douglas-fir	9,535	86.7
Other conifers	1,243	11.3
Alder	220	2.0
Total yield	10,998	100.0

Average value per thousand board feet for the unthinned stand was derived partly from the sale experience on thinnings and partly from valuation of the thinned stand. In the thinned stand, 19.5 percent of the total yield, or 2,287,000 board feet, was harvested as thinnings. Average price received for thinnings over the 5 years, 1956-61, was $12.92 compared with $11.11 for all thinnings. For valuation of the unthinned stand, $12.92 was applied to 2,287,000 board feet, i.e., to that amount taken as thinnings from the thinned stand, and the balance was valued at $25.72 per thousand the same as for the residual thinned stand. This places an average value of $23.06 per thousand on the unthinned stand compared with an average of $22.87 per thousand for the total yield from the thinned stand. With these values, the appraisal of the after-tax value of the inventory volume for alternative management assumptions is as follows:

[4] Derived from the calculated stumpage value by d.b.h. in Schedule A of the Appendix.

	Thinned	Unthinned
1961 inventory _____M board feet	9,427	10,998
Value per thousand board feet __Dollars	25.72	23.06
Total stumpage value _____Dollars	242,462	253,595
Less residual depletion _____Dollars	5,600	7,701
Capital gain _____Dollars	236,862	245,894
Less residual road depreciation or current road cost _____Dollars	9,931	12,355
Less direct selling expense[1] ___Dollars	3,771	4,399
Taxable gain _____Dollars	223,160	229,140
Less tax on gain _____Dollars	55,790	57,285
Net stumpage revenue after tax on gain _____Dollars	167,370	171,855
Less yield tax[2] _____Dollars	15,154	15,850
Less fixed annual expense[3] 1949-61 _____Dollars	0	1,659
Net income from timber property Dollars	152,216	154,346
Plus depletion _____Dollars	5,600	7,701
Plus road residual depreciation[4] _____Dollars	9,931	0
Plus cumulative net cash flow from thinnings _____Dollars	160	0
	167,907	162,047
Incremental income after taxes available under thinning system _____Dollars	5,860	

[1] Calculated at $0.40 per thousand for final clear cut.
[2] Calculated at 12-1/2 percent of total stumpage value and reduced 60 percent to put it on an after-tax basis.
[3] Includes an after-tax interest cost of 3.5 percent per year. For the thinned stand, fixed annual expense was subtracted in calculating net cash flow from thinnings (table 7).
[4] Since the calculation of cumulative net cash flow from thinnings provides for full amortization of the roads, depreciation recovered at time of final harvest becomes net income after taxes.

The foregoing appraisal indicates $5,860, or 3.6 percent, more net cash flow after taxes for blocks A and B under a system of advance roading and thinning than could have been realized had the blocks been left unthinned. This increase in net income amounts to about $1.84 per acre per year. In this appraisal, it comes primarily from the extra yields realized from the capture of mortality through regular thinning. It does not reflect any relative improvement in grade recovery in the thinned stand through redistribution of growth onto higher value trees other than that associated with diameter growth alone. The lower stumpage prices received for the earlier thinnings also lends conservatism to this appraisal of thinning in young-growth Douglas-fir.

In conclusion, holding the stands in blocks A and B through 1961 and thinning lightly with emphasis on leaving higher grade trees was better financial management than holding the stands without thinning. A 3- to 5-year delay in initiation of thinnings; more diversified marketing of thinnings for special products—particularly poles and piling; and quantification of grade improvement attributable to redistribution of growth to better trees, probably would have shown a greater net benefit than that disclosed by the foregoing analysis. This is the answer to the first question posed in this case study.

The Current Management Planning Situation

The situation on the McCleary Experimental Forest has changed considerably since the decision to thin was made in 1949. Experience has shown that periodic thinning, which captures past and expected mortality, was financially superior to not thinning in stands between 43 and 56 years old held for an additional 13 years. The level and quality of growth stock in both stand A and stand B[5] have been substantially improved. With roads established, periodic thinning operations can continue to capture the gross growth in both stands, but is it financially practical to do so?

Stand A is now 56 years old; stand B is 69 years old. What would be the best financial alternative for these stands in the next 20 years? clear cutting and regenerating now? holding the growing stock without thinning to 1981? continuing with light to medium thinnings?

Growth Performance of Stand A

Stand A has an average basal area of 161 square feet per acre. Average number of trees per acre is 113 with an average d.b.h. of 16.2 inches, including both conifers and alder.

[5] Hereinafter, stands A and B refer to the thinned portions of blocks A and B.

Board-foot annual growth percent of the dominant and codominant Douglas-fir trees of the residual stand, as determined from tree remeasurement data on five permanent sample plots, was 6.2 percent for the period 1948-61 (table 8). These tree volumes constitute 50 percent of the current (1961) plot inventory of 28,034 board feet per acre. For the period 1948-61, average stocking for all of stand A was 24,680 board feet per acre with a net annual growth of 1,067 board feet per acre, indicating an average annual stand growth rate of 4.3 percent over the past 13 years. Due to the higher level of growing stock, current growth per acre is somewhat more than 1,067 board feet, and growth rate is approaching 4.0 percent.

In the next decade, volume growth percent will continue to decline due to further increases in growing stock, decreases in board-foot growth per acre, and less ingrowth from trees below 10 inches d.b.h. Value growth percent, however, is expected to be from 1 to 2 percent higher than volume growth percent. At the same time, stocking will be adequate to capture close to full gross growth potential of the site. Accordingly, it is judged that with periodic light thinnings stand A will continue to earn somewhat more than 4-percent return on investment during the next decade and perhaps

Table 8.—Douglas-fir tree size and volume growth percent for stand A, McCleary Experimental Forest

Plot No.	Number of trees[1]	D.b.h. of average tree		Volume of average tree		Volume growth percent
		1948	1961	1948	1961	
		— — Inches — —		— — Board feet — —		
126	5	14.2	18.9	150	385	7.0
130	6	19.7	24.2	354	675	4.7
137	9	12.1	16.1	93	266	7.8
149	8	16.4	20.9	218	483	5.8
158	5	12.2	16.8	95	294	8.4
Average	--	15.1	19.5	180	415	6.2

[1] Sample from a total of 101 trees present on these five 0.2-acre plots. Sample trees are all surviving Douglas-fir 10 inches d.b.h. or larger in 1948 and are mostly dominants and codominants constituting 50 percent of 1961 sawtimber volume for all species.

longer. No further refinement in the economic evaluation of stand A is considered necessary to justify holding it.

The case of stand B, however, is more critical, and a more careful evaluation of its economic outlook is necessary.

Growth Performance of Stand B

The average basal area of stand B for both conifers and alder is 198 square feet per acre. With 82 trees per acre, the average d.b.h. is 21.0 inches.

During the 10-year period following the first thinning, gross increment, determined from five permanent sample plots in an average compartment, was 12,721 board feet per acre, or 1,272 board feet annually. This includes 1,099 board feet of mortality harvested in the 1955 and 1960 thinnings. Total thinning volume (from three thinnings and salvaged mortality) was 19,216 board feet. Growing stock has increased 4,122 board feet since the first thinning, or 32 percent of the gross increment. Table 9 details the performance of stand B between 1950 and 1960 by 5-year periods.

Comparison with permanent sample plot data from the unthinned portion of block B indicates that thinning operations increased yields per

acre by about 189 board feet annually (thinned gross increment of 1,272 board feet against unthinned net of 1,083 board feet). Table 10 gives the increment analysis for the unthinned stand for the 8-year period 1953-61.

Table 10.—Increment analysis of unthinned stands, block B, McCleary Experimental Forest, 1953-61[1]

Year	Volume per acre	Increment per acre			Growth percent
		Gross	Mortality	Net	
— — Board feet, Scribner rule — —					
1953	61,409				
		10,895	2,235	8,660	1.7
1961	70,069				
Annual basis __		1,362	279	1,083	__

[1] Based on the following 0.2-acre plots: 68, 70, 79; 88, 90.

The 1960 board-foot growth percent of stand B is estimated at 2.7, somewhat less than that for the 5 years, 1955-60. For the 20-year period to 1981, the growth percent is expected to fall below 2.7 as growing stock accumulates and growth rate declines with age.

Growth percent for the unthinned check stand in block B is estimated to be 1.7, considerably lower than that for the thinned portion of block B.

Table 9.—Increment analysis of thinned stand, block B, McCleary Experimental Forest, 1950-60[1]

Year of thinning	Volume per acre			Increment per acre			Growth percent
	Before thinning	Thinning removals	After thinning	Gross	Mortality	Net	
— — — — — — Board feet, Scribner rule — — — — — — —							
1950	55,128	10,617	44,511				
				5,883	679	5,204	2.5
1955	49,715	2,883	46,832				
				6,838	420	6,418	2.8
1960	53,250	4,617	48,633				
Total	__	[2]19,216	__	12,721	[3]1,099	11,622	__
Annual basis	__	__	__	1,272	110	1,162	__

[1] Based on the following 0.2-acre plots: 57, 59, 66, 77, 96.
[2] Includes 1,099 board feet of mortality salvaged.
[3] Salvaged in 1955 and 1960 thinnings.

The Main Management Problem and Its Analysis

The main problem centers on stand B. In 1961, net volume per acre was 49,839 board feet, Scribner rule, including 1,067 board feet of alder. Net value was approaching $1,000 an acre, if not more.

Earning rate as a capital asset was below 3 percent insofar as can be ascertained from its volume growth percent. Rates of return available from riskless bank savings or government bonds and from investment opportunities in the private markets for capital were significantly greater than the volume growth percent of stand B. Since earnings from some of these alternative opportunities would be subject to a 50-percent personal income tax for the assumed ownership situation, the after-tax earning rates would range from somewhat less than 2 percent upwards to 5 percent.

It is true that the value growth percent of stand B may be somewhat greater than its volume growth percent due to continuing improvement in tree grade and size. But after 21.7 inches in d.b.h. is attained, the average for conifers in stand B, the favorable influence of grade and size improvement on value growth percent probably falls below 1 percent.

Definition of Management Alternatives

To better determine whether stand B has reached financial maturity, the following practical alternatives are proposed for examination:

Plan A. Clear cut now, and reproduce.
Plan B. Hold without further thinning for 20 years; clear cut and reproduce about 1981.
Plan C. Thin heavily (7,500 board feet per acre) at 5-year intervals for 20 years; clear cut and reproduce about 1981.

Plan D. Thin lightly (4,000 board feet per acre) at 5-year intervals for 20 years; clear cut and reproduce about 1981.

Basic Assumptions

PRICES

Two price assumptions are examined:

(a) Stumpage prices remain constant in terms of 1961 dollars.

(b) Stumpage prices for Douglas-fir increase linearly to $30 per thousand board feet for trees 16 inches in d.b.h. by the year 1981. Stumpage prices of other conifers remain at 65 percent of the stumpage price for Douglas-fir. Alder prices remain constant at $6 per thousand.

The increase in stumpage prices for conifers is assumed to be more likely than constant prices. It is expected that the price trend will not be perfectly linear. The increase to $30 for 16-inch Douglas-fir trees is viewed as a very likely price outlook for the latter part of the planning period, 1976-81, but not before that time.

PLANNING PERIOD

The planning period is taken as 20 years, but it is understood that the action can be altered as circumstances dictate at any time within the next 20 years should the decision favor plans B, C, or D now.

GRADE RECOVERY

The grade of growing stock is assumed to improve with increase in diameter. It is also assumed that improvements in grade will be recognized by the market in accordance with schedule A in the appendix.

STAND COMPOSITION

The ratio of Douglas-fir to other conifers remains constant. Alder of various ages and sizes remains as a scattered and "patchy" component of the stand to 1981.

THINNING REGIME

In practice, thinnings would be carried out on one-fifth of the area of stand B each year. For analytical purposes, income from thinnings is taken only at 5-year intervals, with the first thinning yields calculated for 1966.

GROWTH AND YIELD ESTIMATES

Estimates are the best available knowledge for the management of the lands involved. They are considered physically attainable and the most likely outcome for the individual plans being considered.

COSTS

Direct costs for marking, selling, and supervising thinning is calculated at $2.25 per thousand board feet.

Direct cost for selling and supervising the final clear cut is calculated at $0.40 per thousand board feet.

Road maintenance is calculated at $1 per thousand board feet (thinnings and final clear harvest) for all plans.

Regeneration cost is estimated at $50 per acre.

Undepreciated road investment in 1961 is $41 per acre.

Depletion base is $37 per acre in 1961.

Yield tax is calculated at 3 percent of stumpage revenue in 1949 and increased 1 percent per year thereafter until 1959 when the maximum rate of 12.5 percent was reached.

Annual costs of protection, general administration, and ad valorem taxes, estimated at $0.80 per acre, are assumed fixed at the same average amount per acre for all alternative plans.

Method of Analysis and Decision Criteria

The first objective of the analysis is to compare plans B, C, and D with plan A to determine whether it might be profitable to hold and manage stand B for an additional 20 years. The criterion for holding is a 3.5-percent rate of return on the cash flow, after Federal income taxes, obtainable from harvesting and regenerating stand B now. It is understood that a 3.5-percent return so calculated is an average rate and would involve carrying some growing stock increasing in value at less as well as some increasing at more than 3.5 percent. This is considered practically tolerable where the average rate is 3.5 percent or greater.

If more than one plan meets the foregoing rate of return criterion, then a secondary evaluation would be necessary to determine which plan is best. In such an event, that plan would be best which carries the least amount of growing stock increasing at less than 3.5 percent. Theoretically, this would be the plan with the highest internal rate of return.

From the standpoint of the landowner, the 3.5-percent return after Federal income taxes is taken as his guiding rate of return on investment opportunities of comparable risk. For investments subject to the owner's 50-percent ordinary income tax rate, 3.5 percent after taxes is equivalent to 7 percent before taxes. Some optimistic investors may well expect a higher rate of return on their capital. More conservative investors may be satisfied with a lower return. Their decisions with regard to stand B would vary accordingly.

The rates of return for plans B, C, and D are solved with the following general equation:

$$CF_A - R = \frac{CF_{T5}}{(1.0p)^5} + \frac{CF_{T10}}{(1.0p)^{10}} + \frac{CF_{T15}}{(1.0p)^{15}} + \frac{CF_{F20}}{(1.0p)^{20}} - R$$

CF_A stands for cash flow from plan A. It is the net cash the owner would have from the sale of his timber after all operating costs, yield taxes, and Federal income taxes were paid. CF_A, then, is the capital that would be available for reinvestment under plan A, but which would remain invested in timber if plan B, C, or D is followed.

R is the regeneration cost.

CF_T and CF_F are the cash flow from thinnings and the final clear cut, respectively. For plans C and D, where several different time periods are involved, interest rate (p) must be solved by trial and error, beginning with an

estimated p and working by successive approximations until that p is found which brings about equality in the equation.

The numerical subscripts and exponents are the number of years elapsed from 1961.

Production Schedules and Financial Analyses for Alternative Plans

Production schedules are based on volume, growth, mortality, and tree count data taken from permanent sample plots in stand B. The expected production schedules for each plan and the cash flow analysis and internal rates of return for each plan are presented in tables 11 and 12.

Table 11.—Per-acre production schedules under plans A, B, C, and D for stand B

Plan	Year	Stand before thinning		Thinning harvest			Residual stand			Number of Conifers
		Conifers	Alder	Conifers	D. b. h.	Alder	Conifers	D. b. h.	Alder	
		Bd. ft.	Bd. ft.	Bd. ft.	Inches	Bd. ft.	Bd. ft.	Inches	Bd. ft.	
A	1961	--	--	--	--	--	48,772	21.7	1,067	74.0
B	1961	--	--	--	--	--	48,772	21.7	1,067	74.0
	1966	--	--	--	--	--	54,177	22.9	1,142	71.9
	1971	--	--	--	--	--	59,582	24.1	1,202	70.9
	1976	--	--	--	--	--	64,387	25.2	1,262	68.0
	1981	--	--	--	--	--	[1]70,192	26.3	1,312	66.1
C	1961	--	--	--	--	--	48,772	21.7	1,067	74.0
	1966	54,727	1,142	7,500	18.0	327	47,227	24.0	815	56.1
	1971	52,771	865	7,500	20.0	150	45,271	26.7	715	42.2
	1976	50,174	785	7,500	22.0	170	42,674	29.9	615	31.2
	1981	--	--	--	--	--	47,151	31.4	665	31.2
D	1961	--	--	--	--	--	48,772	21.7	1,067	74.0
	1966	54,727	1,142	4,000	17.0	327	50,727	23.6	815	63.1
	1971	56,682	865	4,000	18.0	150	52,682	25.6	715	53.6
	1976	58,387	785	4,000	19.0	170	54,387	28.2	615	45.1
	1981	--	--	--	--	--	60,092	29.5	665	45.1

[1] Includes 1,000 board feet of salvage.

Table 12.—Financial analysis of alternative plans for stand B

Plan	Year	Stumpage revenue	Depletion[1]	Road depreciation[2]	Direct selling expense[3]	Taxable gain[4]	Net stumpage revenue after tax on gain[5]	Property expenses			Net income from timber property[9]	Cash flow[10]	Regeneration cost	Cumulative net cash flow in 1981[11]		Internal rate of return after taxes
								Road maintenance[6]	Yield tax[7]	Total after-tax cost[8]				Without interest	With interest	Percent
								Dollars per acre								
								CONSTANT STUMPAGE PRICE								
A	1961	1,553	37	41	20	1,455	1,091	50	194	122	969	1,047	50	997	1,984	[1,2]3.5
B	1981	2,596	37	41	29	2,489	1,867	72	325	198	1,669	1,747	50	1,697	1,697	2.7
C	1966	188	4	5	18	161	121	8	24	16	105	114		114	114	
	1971	212	4	4	17	187	140	8	26	17	123	131		245	266	
	1976	244	4	4	17	219	164	8	30	19	145	153		398	469	
	1981	1,900	25	28	19	1,828	1,371	48	238	143	1,228	1,281	50	1,629	1,788	2.9
D	1966	93	2	2	10	79	59	4	12	8	51	55		55	55	
	1971	100	2	2	9	87	65	4	12	8	57	61		116	126	
	1976	107	2	2	9	94	70	4	13	8	62	66		182	216	
	1981	2,398	31	35	24	2,308	1,731	61	300	180	1,551	1,617	50	1,749	1,824	3.0
								RISING STUMPAGE PRICE								
B	1981	3,686	37	41	29	3,579	2,684	72	461	266	2,418	2,496	50	2,446	2,446	4.6
C	1966	207	4	5	18	180	135	8	26	17	118	127		127	127	
	1971	257	4	4	17	232	174	8	32	20	154	162		289	313	
	1976	320	4	4	17	295	221	8	40	24	197	205		494	577	
	1981	2,699	25	28	19	2,627	1,970	48	337	193	1,777	1,830	50	2,274	2,465	4.8
D	1966	103	2	2	10	89	67	4	13	8	59	63		63	63	
	1971	121	2	2	9	108	81	4	15	9	72	76		139	151	
	1976	140	2	2	9	127	95	4	18	11	84	88		227	267	
	1981	3,406	31	35	24	3,316	2,487	61	426	244	2,243	2,309	50	2,486	2,576	5.0

1 Unrecovered depletion in 1961 is $37 per acre.

2 Total unrecovered road depreciation on 245 acres in 1961 is $9,931; the average unrecovered road depreciation is $41 per acre.

3 Calculated at $2.25 per thousand board feet for thinnings and $0.40 per thousand for final clear cut.

4 Stumpage revenue less depletion, depreciation, and direct selling expense.

5 Taxable gain less 25 percent, the tax rate on the gain.

6 Road maintenance is calculated at $1 per thousand board feet.

7 Yield tax is 12-1/2 percent of stumpage revenue.

8 These expenses are offset against ordinary income, which is taxed at 50 percent. After-tax cost, therefore, is one-half the actual cash outlay.

9 Net stumpage revenue after tax on gain less total after-tax property expenses.

10 Net income from timber property plus depletion and road depreciation.

11 Cash flow less regeneration cost. Interest calculated at 3.5 percent, the expected after-tax return on the best comparable investment alternative of owner.

12 The after-tax earning rate on the owner's best alternative investment for the net cash flow ($997) generated by liquidation of stand B in 1961.

The Management Decision

Straightforward application of the 3.5-percent return criterion led to a decision to hold stand B and a choice between plans B, C, and D.

The decision to hold was based upon an expected rising price for young-growth Douglas-fir stumpage. Accordingly, as much attention will have to be given to checking stumpage prices from year to year as to the continued silvicultural care of the stand. Since the internal rates of return for plans B, C, and D all substantially exceed the guiding rate, a somewhat lower price rise than that assumed will satisfy the guiding rate criterion. Any strong evidence against at least partial attainment of the 1981 price expectation, however, would become a criterion for reconsidering the decision to hold.[6]

According to the analysis, plan C is somewhat superior to plan B due apparently to the capture of mortality in plan C, earlier harvest of the slowest growing trees, and somewhat less growing stock after 1961. From the viewpoint of cumulative net cash flow, the difference between plans B and C is only $19, or less than $1 per acre per year. This small difference in net cash flow is attributable to the heavy thinning removals at prices below those assumed for 1981 and the assumption of a slight loss of gross growth in association with the heavy thinnings. For practical purposes, plans B and C are regarded as equally good.

Plan D shows a net cash flow of $130 per acre more than plan B. This difference is substantial and, expanded to the total area of stand B, amounts to $18,850. The advantage in plan D appears to be in the early capture of mortality through light thinning without significant loss of growth per acre and in early removal of trees with very poor growth rates. More volume is carried to 1981 when stumpage prices are assumed to be at the highest level in the next 20 years. Because some mortality is inevitable, even in stands thinned as carefully as stand B, some provision for light thinning seems to be prudent. With other assumptions for plan D equally as tenable as corresponding ones for plans B and C, the difference between plan D and plan B is taken as real and practical.

Thus, the recommended management for stand B is continued light thinning at 5-year intervals, emphasizing harvest of potential mortality and the very slowest growing trees. For practical marking purposes, the slowest growing trees are defined as those whose volume growth percent is expected to fall below 1.5 in the next 5-year thinning period. The 1.5 percent is equivalent to about 3.5 percent in expected value growth. This is based upon the approximate 2-percent difference in the internal earning rates of plans B, C, and D attributable to the rising price expectation.

[6] Under the assumption of constant stumpage prices, it is clear that stand B reached financial maturity and, therefore, harvest age sometime before 1961. From a cash flow viewpoint, even though management of stand B with thinnings may have been superior to holding it without thinning to 1961, the earnings on the capital investment had obviously dropped below 3.5 percent before 1961. For owners with after-tax guiding rates of 3.0 percent or lower, however, holding stand B beyond 1961 could be an attractive alternative even under the assumption that prices will remain constant.

APPENDIX

Computation of Stumpage Prices

Schedule A, column 10, presents the estimated stumpage price by d.b.h. class for second-growth Douglas-fir on McCleary Experimental Forest. The basic data and calculated values used to estimate stumpage price by d.b.h. class are also included.

Schedule B presents estimated stumpage by d.b.h. class and year under the assumption that the stumpage price of 16-inch-d.b.h. Douglas-fir will rise to $30 per thousand board feet in 1981. A linear increase is assumed for the time period between 1961 and 1981.

PROCEDURE IN DEVELOPING SCHEDULE A

In schedule A, columns 1, 2, and 3 give the expected log grade recovery in Scribner board feet from average trees in each d.b.h. class. Three log grades are recognized: SFP (suitable for peeling), No. 2 saw log, and No. 3 saw log, with values of $60, $48.50, and $38.25 per thousand board feet, Scribner rule, respectively. These are log grade prices currently available in the McCleary Experimental Forest market area.

The average log value per thousand board feet, Scribner rule, computed from the foregoing log prices, is given for each d.b.h. class in column 5. These are adjusted in column 6 to reflect actual market experience in 1961. The tree of average d.b.h. for the 1961 thinnings was 14.6 inches. The average price received for logs from the 1961 thinnings was $46 per thousand board feet. The interpolated log value for a tree 14.6 inches in size on the basis of the computed tree values per thousand board feet in column 5 is $41.73. The ratio 46.00/41.73, or 1.1023, is applied to all computed values in column 5 to derive adjusted tree values per thousand board feet in column 6.

In column 7, the logging costs are tabulated for southern pine trees as reported in table 74 of U. S. Department of Agriculture Technical Bulletin 861. These costs do not apply to Douglas-fir, nor are they current cost values. However, the cost relationship between d.b.h. classes is assumed to apply approximately to Douglas-fir trees of the same d.b.h. The cost relationship between d.b.h. classes is expressed as an index in column 8. The index is calculated as a percent of the logging cost for 14.6-inch trees.

Logging costs by d.b.h. for the McCleary Experimental Forest, column 9, are estimated by applying the logging cost index to the average cost, $30.54, experienced in 1961 in logging thinnings whose average d.b.h. was 14.6 inches.

Estimated McCleary stumpage values are then developed in column 10 by subtracting the estimated logging cost per thousand board feet in column 9 from the corresponding adjusted log values in column 6.

PROCEDURE FOR DEVELOPING SCHEDULE B

Stumpage price relatives by d.b.h. class are calculated in column 1, schedule B, from the 1961 McCleary stumpage prices determined in schedule A. The stumpage price relative for 16-inch trees is taken as 100; price relatives for other d.b.h. classes are expressed as a percent of the price for 16-inch trees.

The stumpage prices for 16-inch trees in 1966, 1971, 1976, and 1981 are interpolated on a straight-line basis between the expected $30 price in 1981 and the 1961 price. Stumpage prices for other d.b.h. classes in 1966, 1971, 1976, and 1981 are derived by applying the stumpage price relatives to the price established for 16-inch trees in each respective year.

This method assumes that relative stumpage prices by d.b.h. class remain unchanged between 1961 and 1981.

SCHEDULE A

Estimated stumpage price for second-growth Douglas-fir by d.b.h. class for McCleary Experimental Forest, 1961

D.b.h. (inches)	Log grades			Total volume	Log value[1] per M bd. ft.	Adjusted log value per M bd. ft.	Southern pines logging cost[2]		McCleary Experimental Forest	
	SFP	No. 2	No. 3				Per M bd. ft.	Index	Logging cost per M bd. ft.	Stumpage value per M bd. ft.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	— — — Bd. ft. — — —			Bd. ft.	Dollars	Dollars	Dollars	Percent	Dollars	Dollars
12	--	--	142	142	38.25	42.16	4.99	145.5	44.44	- 2.28
13	--	--	--	178	38.25	42.16	4.15	121.0	36.95	5.21
14	--	54	164	218	40.79	44.96	3.64	106.1	32.40	12.56
14.6	--	--	--	--	41.73	46.00	3.43	100.0	30.54	15.46
15	--	--	--	262	42.36	46.69	3.29	95.9	29.29	17.40
16	--	170	136	306	43.94	48.44	3.07	89.5	27.33	21.11
17	--	--	--	358	44.70	49.27	2.92	85.1	25.99	23.28
18	--	288	122	410	45.45	50.10	2.80	81.6	24.92	25.18
19	--	--	--	462	46.14	50.86	2.69	78.4	23.94	26.92
20	--	441	85	526	46.84	51.63	2.58	75.2	22.97	28.66
21	--	--	--	594	47.88	52.78	2.47	72.0	21.99	30.79
22	100	481	84	665	48.93	53.94	2.36	68.8	21.01	32.93
23	--	--	--	732	49.55	54.62	2.24	65.3	19.94	34.68
24	150	626	36	812	50.17	55.30	2.15	62.7	19.15	36.15
25	--	--	--	899	50.32	55.47	2.07	60.3	18.42	37.05
26	200	747	36	983	50.46	55.62	2.00	58.3	17.80	37.82
27	--	--	--	1,059	51.02	56.24	1.95	56.9	17.38	38.86
28	340	774	36	1,150	51.58	56.86	1.91	55.7	17.01	39.85
29	--	--	--	1,233	51.78	57.08	1.88	54.8	16.74	40.34
30	405	929	--	1,334	51.99	57.31	1.86	54.2	16.55	40.76
31	--	--	--	1,422	52.05	57.37	[3]1.85	53.9	16.46	40.91
32	475	1,038	--	1,513	52.11	57.44	[3]1.85	53.9	16.46	40.98

[1] Log prices = $60 for SFP; $48.50 for No. 2; $38.25 for No. 3.
[2] From table 74 of: Reynolds, R. R., Bond, W. E., and Kirkland, Burt P. Financial aspects of selective cutting in the management of second-growth pine-hardwood forests west of the Mississippi River. U. S. Dept. Agr. Tech. Bul. 861, 118 pp., illus. 1944.
[3] Estimated for these diameter classes.

SCHEDULE B

Expected stumpage prices for second-growth Douglas-fir on McCleary Experimental Forest in 1966, 1971, 1976, and 1981

D.b.h. (inches)	Stumpage price relatives	Expected stumpage prices per thousand board feet in —				
		1961	1966	1971	1976	1981
	(1)	(2)	(3)	(4)	(5)	(6)
		— — — — — — — Dollars — — — — — — —				
15	82.4	17.40	19.22	21.06	22.89	24.72
16	100.0	21.11	23.33	25.56	27.78	30.00
17	110.3	23.28	25.73	28.19	30.64	33.09
18	119.3	25.18	27.83	30.49	33.14	35.79
19	127.5	26.92	29.75	32.59	35.42	38.25
20	135.8	28.66	31.68	34.71	37.73	40.74
21	145.9	30.79	34.04	37.29	40.53	43.77
22	156.0	32.93	36.39	39.87	43.34	46.80
23	164.3	34.68	38.33	42.00	45.64	49.29
24	171.2	36.15	39.94	43.76	47.56	51.36
25	175.5	37.05	40.94	44.86	48.75	52.65
26	179.2	37.82	41.81	45.80	49.78	53.76
27	184.1	38.86	42.95	47.06	51.14	55.23
28	188.8	39.85	44.05	48.26	52.45	56.64
29	191.1	40.34	44.58	48.85	53.09	57.33
30	193.1	40.76	45.05	49.36	53.64	57.93
31	193.8	40.91	45.21	49.54	53.84	58.14
32	194.1	40.98	45.28	49.61	53.92	58.23

Worthington, Norman P., and Fedkiw, John.
1964. Economic considerations in management of Douglas-fir grow-
ing stock—a case study. U. S. Forest Serv. Res. Paper PNW-12,
17 pp., illus.
Results of 13 years' management of two Douglas-fir stands, now 55
and 70 years old, on the McCleary Experimental Forest near Olympia,
Wash., are reviewed. Frequent light commercial thinnings proved financially
superior to no thinning.
Continued light thinning in the younger stand appears economically
desirable. Under constant stumpage prices, the older stand is now finan-
cially mature. If prices rise by 50 percent in 20 years, sustained light thin-
ning is the best of several alternatives for the older stand.